

IN THE CLAIMS

1. (Currently Amended) A process for cleaving one or more hydroperoxides selected from the group consisting of s-butylbenzene hydroperoxide, cumene hydroperoxide, and combinations thereof, the process comprising:

feeding a cleavage reaction feed to a cleavage reactor to produce a cleavage reaction mixture comprising the one or more hydroperoxides wherein the cleavage reactor comprises a pipeline loop reactor comprising one or more heat exchangers effective to maintain the cleavage reaction mixture at a first cleavage reaction temperature; and

subjecting the cleavage reaction mixture to cleavage reaction conditions effective to produce a cleavage reaction product comprising phenol and one or more components selected from the group consisting of methyl ethyl ketone (MEK), acetone, and combinations thereof;

wherein the cleavage reaction conditions comprise a cleavage reaction temperature of less than 75 °C which is sufficiently high to cleave a majority of the one or more hydroperoxides but sufficiently low to produce a first quantity of non-recoverable byproducts from components selected from the group consisting of dimethylbenzyl alcohol (DMBA), ethyl methyl benzyl carbinol (EMBA), and combinations thereof, the first quantity of said non-recoverable byproducts being less than a second quantity of said non-recoverable byproducts produced by the same process at a cleavage reaction temperature of 75 °C or higher.

2. (Original) The process of claim 1 wherein: wherein said cleavage reaction feed comprises from about 0.5 wt.% to 2 wt.% water and a ketone stream selected from the group consisting of an acetone stream, a MEK stream, and a mixed acetone/MEK stream; and

said cleavage reaction conditions comprise feeding the first cleavage reaction feed to a first cleavage reactor and subjecting the first cleavage reaction feed to first cleavage reaction conditions effective to produce a first cleavage reaction mixture comprising a first cleavage reaction product, and feeding the first cleavage reaction product to a second cleavage reactor to produce a second cleavage reaction mixture and subjecting the second cleavage reaction mixture to second cleavage reaction conditions effective to produce a second cleavage reaction product.

3. (Original) The process of claim 2 wherein the second cleavage reaction conditions comprise a second cleavage reaction temperature effective convert DMBA to α -methyl styrene and to convert EMBA to one or more compound selected from the group consisting of α -ethyl styrene (AES), 2-phenyl-2-butene (2P2B), and combinations thereof.

4. (Original) The process of claim 1 wherein said first cleavage reaction conditions comprise feeding to the first cleavage reaction mixture an acid catalyst effective to catalyze the cleavage of hydroperoxides selected from the group consisting of s-butylbenzene hydroperoxide, cumene hydroperoxide, and combinations thereof.

5. (Original) The process of claim 2 wherein said first cleavage reaction conditions comprise feeding to the first cleavage reaction mixture an acid catalyst effective to catalyze the cleavage of hydroperoxides selected from the group consisting of s-butylbenzene hydroperoxide, cumene hydroperoxide, and combinations thereof.

6. (Original) The process of claim 3 wherein said first cleavage reaction conditions comprise feeding to the first cleavage reaction mixture an acid catalyst effective to catalyze the cleavage of hydroperoxides selected from the group consisting of s-butylbenzene hydroperoxide, cumene hydroperoxide, and combinations thereof.

7. (Original) The process of claim 4 wherein the acid catalyst is selected from the group consisting of sulfuric

acid, sulfuric acid anhydride, perchloric acid, and phosphoric acid.

8. (Original) The process of claim 5 wherein the acid catalyst is selected from the group consisting of sulfuric acid, sulfuric acid anhydride, perchloric acid, and phosphoric acid.

9. (Original) The process of claim 6 wherein the acid catalyst is selected from the group consisting of sulfuric acid, sulfuric acid anhydride, perchloric acid, and phosphoric acid.

10. (Original) The process of claim 4 wherein the acid catalyst comprises sulfuric acid.

11. (Original) The process of claim 5 wherein the acid catalyst comprises sulfuric acid.

12. (Original) The process of claim 6 wherein the acid catalyst comprises sulfuric acid.

13. (Currently Amended) The process of claim 6 wherein ~~the first cleavage reactor and the second cleavage reactor are~~ is selected from the group consisting of plug-flow reactors, plug-flow reactors with recycle, and continuous stirred tank reactors.

14. (Currently Amended) The process of claim 12 wherein ~~the first cleavage reactor and the second cleavage reactor are~~ is selected from the group consisting of plug-flow reactors, plug-flow reactors with recycle, and continuous stirred tank reactors.

15-18. (Cancelled)

19. (Original) The process of claim 1 wherein the first cleavage reaction conditions comprise

a first cleavage reaction temperature of from about 45°C to about 70°C;

a first cleavage reaction pressure sufficiently high to maintain the first cleavage reaction mixture in the liquid phase; and,

a first cleavage reaction residence time effective to cleave about 95% or more of s-butylbenzene hydroperoxide in the first cleavage reaction mixture to phenol and MEK and to cleave about 95% or more of

cumene hydroperoxide in the first cleavage reaction mixture to phenol and acetone.

20. (Original) The process of claim 2 wherein the first cleavage reaction conditions comprise

a first cleavage reaction temperature of from about 45°C to about 70°C;

a first cleavage reaction pressure sufficiently high to maintain the first cleavage reaction mixture in the liquid phase; and,

a first cleavage reaction residence time effective to cleave about 95% or more of s-butylbenzene hydroperoxide in the first cleavage reaction mixture to phenol and MEK and to cleave about 95% or more of cumene hydroperoxide in the first cleavage reaction mixture to phenol and acetone.

21. (Original) The process of claim 3 wherein the first cleavage reaction conditions comprise

a first cleavage reaction temperature of from about 45°C to about 70°C;

a first cleavage reaction pressure sufficiently high to maintain the first cleavage reaction mixture in the liquid phase; and,

a first cleavage reaction residence time effective to cleave about 95% or more of s-butylbenzene hydroperoxide in the first cleavage reaction mixture to phenol and MEK and to cleave about 95% or more of cumene hydroperoxide in the first cleavage reaction mixture to phenol and acetone.

22. (Original) The process of claim 4 wherein the first cleavage reaction conditions comprise

a first cleavage reaction temperature of from about 45°C to about 70°C;

a first cleavage reaction pressure sufficiently high to maintain the first cleavage reaction mixture in the liquid phase; and,

a first cleavage reaction residence time effective to cleave about 95% or more of s-butylbenzene

hydroperoxide in the first cleavage reaction mixture to phenol and MEK and to cleave about 95% or more of cumene hydroperoxide in the first cleavage reaction mixture to phenol and acetone.

23. (Original) The process of claim 6 wherein the first cleavage reaction conditions comprise

a first cleavage reaction temperature of from about 45°C to about 70°C;

a first cleavage reaction pressure sufficiently high to maintain the first cleavage reaction mixture in the liquid phase; and,

a first cleavage reaction residence time effective to cleave about 95% or more of s-butylbenzene hydroperoxide in the first cleavage reaction mixture to phenol and MEK and to cleave about 95% or more of cumene hydroperoxide in the first cleavage reaction mixture to phenol and acetone.

24. (Original) The process of claim 12 wherein the first cleavage reaction conditions comprise

a first cleavage reaction temperature of from about 45°C to about 70°C;

a first cleavage reaction pressure sufficiently high to maintain the first cleavage reaction mixture in the liquid phase; and,

a first cleavage reaction residence time effective to cleave about 95% or more of s-butylbenzene hydroperoxide in the first cleavage reaction mixture to phenol and MEK and to cleave about 95% or more of cumene hydroperoxide in the first cleavage reaction mixture to phenol and acetone.

25. (Original) The process of claim 23 wherein the first cleavage reaction temperature is from about 45°C to about 60°C.

26. (Original) The process of claim 24 wherein the first cleavage reaction temperature is from about 45°C to about 60°C.

27. (Original) The process of claim 23 wherein the first cleavage reaction temperature is from about 45°C to about 55°C.

28. (Original) The process of claim 24 wherein the first cleavage reaction temperature is from about 45°C to about 55°C.

29. (Original) The process of claim 27 wherein the first cleavage reaction conditions comprise a first cleavage reaction pressure of about 0.5 atmosphere or more.

30. (Original) The process of claim 28 wherein the first cleavage reaction conditions comprise a first cleavage reaction pressure of about 0.5 atmosphere or more.

31. (Original) The process of claim 1 wherein the first cleavage reaction conditions comprise recirculating a recycle flow of the first cleavage reaction mixture through the first cleavage reactor.

32. (Original) The process of claim 2 wherein the first cleavage reaction conditions comprise recirculating a recycle flow of the first cleavage reaction mixture through the first cleavage reactor.

33. (Original) The process of claim 3 wherein the first cleavage reaction conditions comprise recirculating a recycle flow of the first cleavage reaction mixture through the first cleavage reactor.

34. (Original) The process of claim 4 wherein the first cleavage reaction conditions comprise recirculating a recycle flow of the first cleavage reaction mixture through the first cleavage reactor.

35. (Original) The process of claim 6 wherein the first cleavage reaction conditions comprise recirculating a recycle flow of the first cleavage reaction mixture through the first cleavage reactor.

36. (Original) The process of claim 12 wherein the first cleavage reaction conditions comprise recirculating a recycle flow of the first cleavage reaction mixture through the first cleavage reactor.

37. (Original) The process of claim 24 wherein the first cleavage reaction conditions comprise recirculating a recycle flow of the first cleavage reaction mixture through the first cleavage reactor.

38. (Original) The process of claim 31 further comprising withdrawing the first cleavage reaction product

from the first cleavage reactor at a first cleavage reaction product withdrawal point upstream of the first cleavage reactor feed.

39. (Original) The process of claim 37 further comprising withdrawing the first cleavage reaction product from the first cleavage reactor at a first cleavage reaction product withdrawal point upstream of the first cleavage reactor feed.

40. (Original) The process of claim 31 wherein the recycle flow is greater than the first cleavage reactor feed flow.

41. (Original) The process of claim 33 wherein the recycle flow is greater than the first cleavage reactor feed flow.

42. (Original) The process of claim 35 wherein the recycle flow is greater than the first cleavage reactor feed flow.

43. (Original) The process of claim 37 wherein the recycle flow is greater than the first cleavage reactor feed flow.

44. (Original) The process of claim 39 wherein the recycle flow is greater than the first cleavage reactor feed flow.

45. (Original) The process of claim 31 wherein a ratio of the recycle flow to the first cleavage reactor feed flow is from about 10:1 to about 100:1 on a weight basis.

46. (Original) The process of claim 35 wherein a ratio of the recycle flow to the first cleavage reactor feed flow is from about 10:1 to about 100:1 on a weight basis.

47. (Original) The process of claim 31 wherein a ratio of the recycle flow to the first cleavage reactor feed flow is from about 20:1 to 40:1 on a weight basis.

48. (Original) The process of claim 35 wherein a ratio of the recycle flow to the first cleavage reactor feed flow is from about 20:1 to 40:1 on a weight basis.

49. (Original) The process of claim 43 wherein the first cleavage reaction conditions comprise a first cleavage reaction residence time effective to cleave from about 95% to

about 98% of s-butylbenzene hydroperoxide in the first cleavage reaction mixture to phenol and MEK.

50. (Original) The process of claim 41 wherein the first cleavage reaction residence time is from about 1 minute to about 10 minutes.

51. (Original) The process of claim 43 wherein the first cleavage reaction residence time is from about 1 minute to about 10 minutes.

52. (Currently Amended) The process of claim 42 wherein the second cleavage reactor comprises a once through plug flow reactor.

53. (Original) The process of claim 35 further comprising adding the acid catalyst to a first cleavage reaction mixture side stream at one or more acid addition points.

54. (Original) The process of claim 43 further comprising adding the acid catalyst to a first cleavage reaction mixture side stream at one or more acid addition points.

55. (Original) The process of claim 3 wherein the second cleavage reaction conditions comprise a second cleavage reaction temperature and a second cleavage reaction residence time effective to cleave 95 wt.% or more of the hydroperoxides remaining in the second cleavage reaction mixture.

56. (Original) The process of claim 44 wherein the second cleavage reaction conditions comprise a second cleavage reaction temperature and a second cleavage reaction residence time effective to cleave 95 wt.% or more of the hydroperoxides remaining in the second cleavage reaction mixture.

57. (Original) The process of claim 38 further comprising withdrawing the first cleavage reaction mixture side stream between the first cleavage reaction product withdrawal point and the first cleavage reactor feed point.

58. (Original) The process of claim 39 further comprising withdrawing the first cleavage reaction mixture side stream between the first cleavage reaction product withdrawal point and the first cleavage reactor feed point.

59. (Original) The process of claim 56 wherein the second cleavage reaction conditions are effective to convert 70 wt.% or more of DMBA in the first cleavage reaction product to AMS.

60. (Original) The process of claim 59 wherein the second cleavage reaction conditions are effective to convert 70 wt.% or more of EMBA in the first cleavage reaction product to AES, 2P2B, and combinations thereof.

61. (Original) The process of claim 56 wherein the second cleavage reaction conditions are effective to convert 75 wt.% or more of DMBA in the first cleavage reaction product to AMS.

62. (Original) The process of claim 59 wherein the second cleavage reaction conditions are effective to convert 75 wt.% or more of EMBA in the first cleavage reaction product to AES, 2P2B, and combinations thereof.

63. (Original) The process of claim 56 wherein the second cleavage reaction conditions are effective to convert 85 wt.% or more of DMBA in the first cleavage reaction product to AMS.

64. (Original) The process of claim 59 wherein the second cleavage reaction conditions are effective to convert 85 wt.% or more of EMBA in the first cleavage reaction product to AES, 2P2B, and combinations thereof.

65. (Currently amended) A process for cleaving ~~one or more hydroperoxides selected from the group consisting of a~~ mixture of s-butylbenzene hydroperoxide[[,]] and cumene hydroperoxide, ~~and combinations thereof,~~ the process comprising:

feeding to a first cleavage reactor at a first cleavage reaction feed flow a cleavage reaction feed comprising from about 0.5 wt.% to 2 wt.% water, a ketone stream selected from the group consisting of an acetone stream, a MEK stream, and a mixed acetone/MEK stream, s-butylbenzene hydroperoxide and cumene hydroperoxide, and an acid catalyst effective to catalyze the cleavage of ~~hydroperoxides selected from the group consisting of s-butylbenzene hydroperoxide[[,]] and cumene hydroperoxide,~~ and combinations thereof, producing a first cleavage reaction mixture ~~comprising one or more hydroperoxides selected from the group consisting of said s-butylbenzene, said cumene hydroperoxide, and combinations thereof;~~

exposing said first cleavage reaction mixture to first cleavage reaction conditions effective to cleave s-butylbenzene hydroperoxide to phenol and MEK and to cleave cumene hydroperoxide to phenol and acetone, wherein said first cleavage reaction conditions comprise:

- a first cleavage reaction temperature of less than 75 °C which is sufficiently high to cleave a majority of the ~~one or more~~ hydroperoxides but sufficiently low to produce a first quantity of non-recoverable byproducts from components selected from the group consisting of dimethylbenzyl alcohol (DMBA), ethyl methyl benzyl carbinol (EMBA), and combinations thereof, the first quantity of said non-recoverable byproducts being less than a second quantity of said non-recoverable byproducts produced by the same process at a cleavage reaction temperature of 75 °C or higher;
- a first cleavage reaction pressure sufficiently high to maintain the first cleavage reaction mixture in the liquid phase;
- recirculating a recycle flow of the first cleavage reaction mixture through the first cleavage reactor, said recycle flow being greater than the first cleavage reactor feed flow; and
- feeding the first cleavage reaction product to a second cleavage reactor to produce a second cleavage reaction mixture;
- subjecting the second cleavage reaction mixture to second cleavage reaction conditions comprising a second cleavage reaction temperature effective to cleave a ~~majority of the one or more~~ to cleave 95 wt.% or more of the hydroperoxides remaining in the second cleavage reaction mixture, to convert a majority of DMBA in the second cleavage reaction mixture to α -methyl styrene, and to convert a majority of EMBA in the second cleavage reaction mixture to one or more compound selected from the group consisting of α -

ethyl styrene (AES), 2-phenyl-2-butene (2P2B), and combinations thereof, producing a second cleavage reaction product; and,

subjecting the second cleavage reaction product to final conditions effective to produce a final cleavage reaction product comprising phenol and one or more component selected from the group consisting of methyl ethyl ketone (MEK), acetone, and combinations thereof.

66. (Original) The process of claim 65 wherein a ratio of the recycle flow to the first cleavage reactor feed flow is from about 10:1 to about 100:1 on a weight basis.

67. (Original) The process of claim 65 wherein a ratio of the recycle flow to the first cleavage reactor feed flow is from about 20:1 to 40:1 on a weight basis.

68. (Original) The process of claim 65 wherein the first cleavage reaction conditions comprise a first cleavage reaction residence time effective to cleave about 95% or more of s-butylbenzene hydroperoxide in the first cleavage reaction mixture to phenol and MEK.

69. (Original) The process of claim 67 wherein the first cleavage reaction conditions comprise a first cleavage reaction residence time effective to cleave about 95% or more of s-butylbenzene hydroperoxide in the first cleavage reaction mixture to phenol and MEK.

70. (Original) The process of claim 65 wherein the first cleavage reaction conditions comprise a first cleavage reaction residence time effective to cleave from about 95% to about 98% of s-butylbenzene hydroperoxide in the first cleavage reaction mixture to phenol and MEK.

71. (Original) The process of claim 65 wherein the first cleavage reaction conditions comprise a first cleavage reaction residence time effective to cleave about 95% or more of cumene hydroperoxide in the first cleavage reaction mixture to phenol and acetone.

72. (Original) The process of claim 68 wherein the first cleavage reaction conditions comprise a first cleavage reaction residence time effective to cleave about 95% or more

of cumene hydroperoxide in the first cleavage reaction mixture to phenol and acetone.

73. (Original) The process of claim 69 wherein the first cleavage reaction conditions comprise a first cleavage reaction residence time effective to cleave about 95% or more of cumene hydroperoxide in the first cleavage reaction mixture to phenol and acetone.

74. (Original) The process of claim 72 wherein the first cleavage reaction residence time is from about 1 minute to about 10 minutes.

75. (Original) The process of claim 73 wherein the first cleavage reaction residence time is from about 1 minute to about 10 minutes.

76. (Original) The process of claim 72 wherein the acid catalyst is selected from the group consisting of sulfuric acid, sulfuric acid anhydride, perchloric acid, and phosphoric acid.

77. (Original) The process of claim 72 wherein the acid catalyst comprises sulfuric acid.

78. (Original) The process of claim 72 further comprising adding the acid catalyst to a first cleavage reaction mixture side stream at one or more acid addition points.

79. (Original) The process of claim 76 further comprising adding the acid catalyst to a first cleavage reaction mixture side stream at one or more acid addition points.

80. (Original) The process of claim 77 further comprising adding the acid catalyst to a first cleavage reaction mixture side stream at one or more acid addition points.

81. (Original) The process of claim 65 further comprising withdrawing the first cleavage reaction mixture side stream between the first cleavage reaction product withdrawal point and the first cleavage reactor feed point.

82. (Original) The process of claim 78 further comprising withdrawing the first cleavage reaction product from the first cleavage reactor at a first cleavage reaction

product withdrawal point upstream of the first cleavage reactor feed.

83. (Original) The process of claim 65 wherein the second cleavage reaction conditions are effective to convert 70 wt.% or more of DMBA in the first cleavage reaction product to AMS.

84. (Original) The process of claim 65 wherein the second cleavage reaction conditions are effective to convert 70 wt.% or more of EMBA in the first cleavage reaction product to AES, 2P2B, and combinations thereof.

85. (Original) The process of claim 65 wherein the second cleavage reaction conditions are effective to convert 75 wt.% or more of DMBA in the first cleavage reaction product to AMS.

86. (Original) The process of claim 65 wherein the second cleavage reaction conditions are effective to convert 75 wt.% or more of EMBA in the first cleavage reaction product to AES, 2P2B, and combinations thereof.

87. (Original) The process of claim 65 wherein the second cleavage reaction conditions are effective to convert 85 wt.% or more of DMBA in the first cleavage reaction product to AMS.

88. (Original) The process of claim 65 wherein the second cleavage reaction conditions are effective to convert 85 wt.% or more of EMBA in the first cleavage reaction product to AES, 2P2B, and combinations thereof.

89. (Original) A process for cleaving one or more hydroperoxides selected from the group consisting of s-butylbenzene hydroperoxide, cumene hydroperoxide, and combinations thereof, the process comprising:

feeding a cleavage reaction feed comprising from about 0.5 wt.% to 2 wt.% water, a ketone stream selected from the group consisting of an acetone stream, a MEK stream, and a mixed acetone/MEK stream, and an acid catalyst to a first cleavage reactor at a first cleavage reaction feed flow, producing a first cleavage reaction mixture, said acid catalyst being effective to catalyze the cleavage of hydroperoxides selected from the group consisting of s-butylbenzene hydroperoxide, cumene hydroperoxide, and combinations thereof;

exposing said first cleavage reaction mixture to first cleavage reaction conditions effective to produce a first cleavage reaction product comprising the one or more hydroperoxides, said first cleavage reaction conditions comprising a first cleavage reaction temperature of less than 75 °C and a first cleavage reaction pressure sufficiently high to maintain the first cleavage reaction mixture in the liquid phase, said first cleavage reaction conditions further comprising recirculating a recycle flow of the first cleavage reaction mixture through the first cleavage reactor, wherein the ratio of said recycle flow to said first cleavage reactor feed flow is from about 10:1 to about 100:1 on a weight basis, said first cleavage reaction conditions being effective to cleave about 95% or more of s-butylbenzene hydroperoxide in the first cleavage reaction mixture to phenol and MEK, to cleave about 95% or more of cumene hydroperoxide in the first cleavage reaction mixture to phenol and acetone, and to produce a first quantity of non-recoverable byproducts from components selected from the group consisting of dimethylbenzyl alcohol (DMBA), ethyl methyl benzyl carbinol (EMBA), and combinations thereof, the first quantity of said non-recoverable byproducts being less than a second quantity of said non-recoverable byproducts produced by the same process at a cleavage reaction temperature of 75 °C or higher; and feeding the first cleavage reaction product to a second cleavage reactor to produce a second cleavage reaction mixture; subjecting the second cleavage reaction mixture to second cleavage reaction conditions comprising a second cleavage reaction temperature effective to cleave 95 wt.% or more of the hydroperoxides remaining in the second cleavage reaction mixture, to convert 70 wt% or more of DMBA in the second cleavage reaction mixture to α -methyl styrene, and to convert 70 wt.%

or more of EMBA in the second cleavage reaction mixture to one or more compound selected from the group consisting of α -ethyl styrene (AES), 2-phenyl-2-butene (2P2B), and combinations thereof, producing a second cleavage reaction product; and, subjecting the second cleavage reaction product to final conditions effective to produce a final cleavage reaction product comprising phenol and one or more component selected from the group consisting of methyl ethyl ketone (MEK), acetone, and combinations thereof.

90. (Original) The process of claim 89 wherein said second cleavage reaction conditions comprise a second cleavage reaction temperature effective to cleave 95 wt.% or more of the hydroperoxides remaining in the second cleavage reaction mixture, to convert 75 wt% or more of DMBA in the second cleavage reaction mixture to α -methyl styrene, and to convert 75 wt.% or more of EMBA in the second cleavage reaction mixture to one or more compound selected from the group consisting of α -ethyl styrene (AES), 2-phenyl-2-butene (2P2B), and combinations thereof.

91. (Original) The process of claim 89 wherein said second cleavage reaction conditions comprise a second cleavage reaction temperature effective to cleave 95 wt.% or more of the hydroperoxides remaining in the second cleavage reaction mixture, to convert 85 wt% or more of DMBA in the second cleavage reaction mixture to α -methyl styrene, and to convert 85 wt.% or more of EMBA in the second cleavage reaction mixture to one or more compound selected from the group consisting of α -ethyl styrene (AES), 2-phenyl-2-butene (2P2B), and combinations thereof

92. (Original) The process of claim 89 wherein the first cleavage reactor is a pipeline loop reactor comprising one or more heat exchangers effective to maintain a first cleavage reaction mixture at a first cleavage reaction temperature.

93. (Original) The process of claim 90 wherein the first cleavage reactor is a pipeline loop reactor comprising one or

more heat exchangers effective to maintain a first cleavage reaction mixture at a first cleavage reaction temperature.

94. (Original) The process of claim 91 wherein the first cleavage reactor is a pipeline loop reactor comprising one or more heat exchangers effective to maintain a first cleavage reaction mixture at a first cleavage reaction temperature.

95. (Original) The process of claim 89 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 70°C.

96. (Original) The process of claim 90 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 70°C.

97. (Original) The process of claim 91 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 70°C.

98. (Original) The process of claim 92 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 70°C.

99. (Original) The process of claim 93 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 70°C.

100. (Original) The process of claim 94 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 70°C.

101. (Original) The process of claim 89 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 60°C.

102. (Original) The process of claim 90 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 60°C.

103. (Original) The process of claim 91 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 60°C.

104. (Original) The process of claim 92 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 60°C.

105. (Original) The process of claim 93 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 60°C.

106. (Original) The process of claim 94 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 60°C.

107. (Original) The process of claim 91 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 55°C.

108. (Original) The process of claim 92 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 55°C.

109. (Original) The process of claim 93 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 55°C.

110. (Original) The process of claim 94 wherein the first cleavage reaction conditions comprise a first cleavage reaction temperature of from about 45°C to about 55°C.

111. (Original) The process of claim 110 wherein the first cleavage reaction conditions comprise a first cleavage reaction pressure of about 0.5 or less.

112. (Original) The process of claim 89 further comprising withdrawing the first cleavage reaction product from the first cleavage reactor at a first cleavage reaction product withdrawal point upstream of the first cleavage reactor feed.

113. (Original) The process of claim 111 further comprising withdrawing the first cleavage reaction product from the first cleavage reactor at a first cleavage reaction product withdrawal point upstream of the first cleavage reactor feed.

114. (Original) The process of claim 89 wherein a ratio of the recycle flow to the first cleavage reactor feed flow is from about 20:1 to 40:1 on a weight basis.

115. (Original) The process of claim 111 wherein a ratio of the recycle flow to the first cleavage reactor feed flow is from about 20:1 to 40:1 on a weight basis.

116. (Original) The process of claim 111 wherein the first cleavage reaction residence time is from about 1 minute to about 10 minutes.

117. (Original) The process of claim 116 wherein the acid catalyst is selected from the group consisting of sulfuric acid, sulfuric acid anhydride, perchloric acid, and phosphoric acid.

118. (Original) The process of claim 89 wherein the acid catalyst comprises sulfuric acid.

119. (Original) The process of claim 116 wherein the acid catalyst comprises sulfuric acid.

120. (Original) The process of claim 89 further comprising adding the acid catalyst to a first cleavage reaction mixture side stream at one or more acid addition points.

121. (Original) The process of claim 119 further comprising adding the acid catalyst to a first cleavage reaction mixture side stream at one or more acid addition points.

122. (Original) The process of claim 98 further comprising withdrawing the first cleavage reaction mixture side stream between the first cleavage reaction product withdrawal point and the first cleavage reactor feed point.

123. (Original) The process of claim 99 further comprising withdrawing the first cleavage reaction mixture side stream between the first cleavage reaction product withdrawal point and the first cleavage reactor feed point.

124. (Original) The process of claim 122 wherein the amount of acid catalyst fed to the first cleavage reactor is from about 0.005% to about 0.1% by weight based on the first cleavage reactor feed flow.

125. (Original) The process of claim 123 wherein the amount of acid catalyst fed to the first cleavage reactor is from about 0.005% to about 0.1% by weight based on the first cleavage reactor feed flow.

126. (Original) The process of claim 89 wherein the second cleavage reactor comprises a once through plug flow reactor.

127. (Original) The process of claim 124 wherein the second cleavage reactor comprises a once through plug flow reactor.

128. (Original) The process of claim 125 wherein the second cleavage reactor comprises a once through plug flow reactor.

129. (Original) The process of claim 89 wherein the second cleavage reaction conditions comprise a second cleavage reaction residence time of from about 5 seconds to about 1 minute.

130. (Original) The process of claim 89 wherein the second cleavage reaction temperature is from about 60 °C to about 130 °C.

131. (Original) The process of claim 128 wherein the second cleavage reaction temperature is from about 60 °C to about 130 °C.

132. (Original) The process of claim 129 wherein the second cleavage reaction temperature is from about 60 °C to about 130 °C.

133. (Original) The process of claim 109 wherein the second cleavage reaction temperature is from about 70 °C to about 120 °C.

134. (Original) The process of claim 130 wherein the second cleavage reaction pressure is about 30 psig or more.

135. (Original) The process of claim 89 further comprising taking multiple exotherm measurements to verify the rate of the cleavage reaction.

136. (Original) The process of claim 134 further comprising taking multiple exotherm measurements to verify the rate of the cleavage reaction.

137. (Original) The process of claim 135 further comprising controlling the amount of acid catalyst added to the first cleavage reaction mixture based on the multiple exotherm measurements.

138. (Original) The process of claim 136 further comprising controlling the amount of acid catalyst added to the first cleavage reaction mixture based on the multiple exotherm measurements.

139. (Original) The process of claim 137 wherein taking the multiple exotherm measurements comprises

taking a first reaction mixture side stream exotherm measurement;

taking a first cleavage reactor (FCR) exotherm measurement; and,

taking a second cleavage reactor (SCR) exotherm measurement.

140. (Original) The process of claim 138 wherein taking the multiple exotherm measurements comprises

taking a first reaction mixture side stream exotherm measurement;

taking a first cleavage reactor (FCR) exotherm measurement; and,

taking a second cleavage reactor (SCR) exotherm measurement.

141. (New) A process for cleaving one or more hydroperoxides selected from the group consisting of s-butylbenzene hydroperoxide, cumene hydroperoxide, and combinations thereof, the process comprising:

feeding a cleavage reaction feed to a cleavage reactor to produce a cleavage reaction mixture comprising the one or more hydroperoxides; and

subjecting the cleavage reaction mixture to cleavage reaction conditions effective to produce a cleavage reaction product comprising phenol and one or more components selected from the group consisting of methyl ethyl ketone (MEK), acetone, and combinations thereof;

wherein the cleavage reaction conditions comprise a cleavage reaction temperature of less than 75 °C which is sufficiently high to cleave a majority of the one or more hydroperoxides but sufficiently low to produce a first quantity of non-recoverable byproducts from components selected from the group consisting of dimethylbenzyl alcohol (DMBA), ethyl methyl benzyl carbinol (EMBA), and combinations thereof, the first quantity of said non-recoverable byproducts being less than a second quantity of said non-recoverable byproducts produced by the same process at a cleavage reaction temperature of 75 °C or higher; and

feeding the cleavage reaction product to a second cleavage reactor comprising a once through plug flow reactor.

142. (New) A process for cleaving one or more hydroperoxides selected from the group consisting of s-butylbenzene hydroperoxide, cumene hydroperoxide, and combinations thereof, the process comprising:

feeding a cleavage reaction feed comprising the one or more hydroperoxides and from about 0.5 wt.% to 2 wt.% water and a ketone stream selected from the group consisting of an acetone stream, a MEK stream, and a mixed acetone/MEK stream to a first cleavage reactor to produce a cleavage reaction mixture; subjecting the cleavage reaction mixture to cleavage reaction conditions effective to produce a first cleavage reaction product comprising phenol and one or more components selected from the group consisting of methyl ethyl ketone (MEK), acetone, and combinations thereof;

wherein the cleavage reaction conditions comprise a cleavage reaction temperature of less than 75 °C which is sufficiently high to cleave a majority of the one or more hydroperoxides but sufficiently low to produce a first quantity of non-recoverable byproducts from components selected from the group consisting of dimethylbenzyl alcohol (DMBA), ethyl

methyl benzyl carbinol (EMBA), and combinations thereof, the first quantity of said non-recoverable byproducts being less than a second quantity of said non-recoverable byproducts produced by the same process at a cleavage reaction temperature of 75 °C or higher; and

feeding the first cleavage reaction product to a second cleavage reactor operating at second cleavage reaction conditions comprising a second cleavage reaction temperature and a second cleavage residence time effective to convert DMBA to α -methyl styrene and to convert EMBA to one or more compound selected from the group consisting of α -ethyl styrene (AES), 2-phenyl-2-butene (2P2B), and combinations thereof and to cleave 95 wt% or more of the hydroperoxides remaining in the second cleavage reaction mixture.

143. (New) The process of claim 142 wherein the second cleavage reaction conditions are effective to convert 70 wt.% or more of DMBA in the first cleavage reaction product to AMS.

144. (New) The process of claim 142 wherein the second cleavage reaction conditions are effective to convert 70 wt.% or more of EMBA in the first cleavage reaction product to AES, 2P2B, and combinations thereof.

145. (New) The process of claim 56 wherein the second cleavage reaction conditions are effective to convert 85 wt.% or more of DMBA in the first cleavage reaction product to AMS.

146. (New) The process of claim 59 wherein the second cleavage reaction conditions are effective to convert 85 wt.% or more of EMBA in the first cleavage reaction product to AES, 2P2B, and combinations thereof.